Operative Techniques in Thoracic and Cardiovascular Surgery

Primary Repair of Esophageal Perforation

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Perforation of the esophagus results in significant morbidity and potential mortality. Determinants of morbidity and mortality are the cause of the injury, location of the injury along the esophagus, and delay in diagnosis and treatment. Spontaneous perforation, such as postemetic Boerhaave's syndrome, accounts for up to 36% of esophageal perforation, 19% of iatrogenic injuries, and 7% of external trauma.[1] Delay in diagnosis greater than 24 hours doubles the resultant mortality. However, regardless of time to diagnosis, in the absence of associated malignancy, severe esophageal dysmotility, or gastroesophageal reflux stricture, several reports indicate the advantages and success of primarily repairing esophageal injuries.[2-4]

Causes of esophageal perforation can be divided into instrumental and noninstrumental. Instrumental causes include endoscopy, both rigid and flexible, dilation of strictures or the esophagogastric junction (EGJ) by pneumatic balloon dilation or bouginage, and airway intubation. Noninstrumental causes include barogenic, penetrating, and operative trauma. The most common etiology of barogenic trauma is Boerhaave's syndrome. In 1723, Dr. Hermann Boerhaave detailed in his report, "History of a Grievous Disease Not Previously Described," a postmortem on the Dutch admiral, Baron Jan Germit von Wassenaer.[5] The Baron had a habit of self-inducing emesis after heavy meals. After a dinner of duck and beer, the Baron vomited, experienced an acute ripping sensation, and died 18 hours later. A postmortem found a transverse tear of the distal esophagus, just proximal to the EGJ.

Although esophageal perforation may occur anywhere, certain types of esophageal injuries have a predilection to occurring at key anatomic areas. These areas correspond to natural points of narrowing, specifically, the criopharyngeus muscle of the cervical esophagus, the area of broncho-aortic constriction at the proximal one-third of the esophagus, and the distal EGJ (Fig. 1). Iatrogenic cervical esophageal injuries, especially endoscopy, commonly occur at Killian's triangle, an area lacking posterior esophageal muscularis (Fig. 2). This narrow area is bordered by the horizontal cricopharyngeus muscle inferiorly and the oblique inferior constrictor muscles superiorly. Ingested foreign bodies often become lodged at the broncho-aortic constriction, causing localized injury. Barogenic trauma occurs most frequently near the EGJ.

In cervical esophageal perforation, patients often present with symptoms of neck pain, dysphagia, odynophagia, dysphonia, and subcutaneous emphysema. Symptoms of intrathoracic esophageal perforation are often more extreme and include chest pain, tachycardia, fever, leukocytosis, and hypotension. Intrathoracic esophageal perforation may rapidly contaminate the mediastinum, causing chemical irritation, inflammation, and sepsis. Chemical injury from the disrupted esophagus may cause the overlying pleura to rupture, and negative intrathoracic pressure draws saliva, gastric juice, and bacteria from the esophageal lumen into the pleural space, eventually leading to marked fluid shifts and shock.

Several diagnostic tests play important roles in identifying esophageal perforation. A chest radiograph should be obtained, looking for subcutaneous emphysema and pneumomediastinum. Contrast esophagography is the gold standard. Water-soluble gastrograffin should be avoided, as it is hypertonic and aspiration may lead to pneumonitis.[6] Thin barium is an effective and safe contrast agent for esophagography and detects even small defects.[7] Chest computed tomography identifies pneumomediastinum, pneumoperitoneum, pleural effusions, and esophageal thickening. Flexible endoscopy is valuable and may identify a high-grade stricture or malignancy that would steer the surgeon from primary repair to esophagectomy.

Once the diagnosis of esophageal injury is confirmed, prompt surgical treatment is mandatory. In the following sections, we describe primary repair of the cervical and intrathoracic esophageal perforation.

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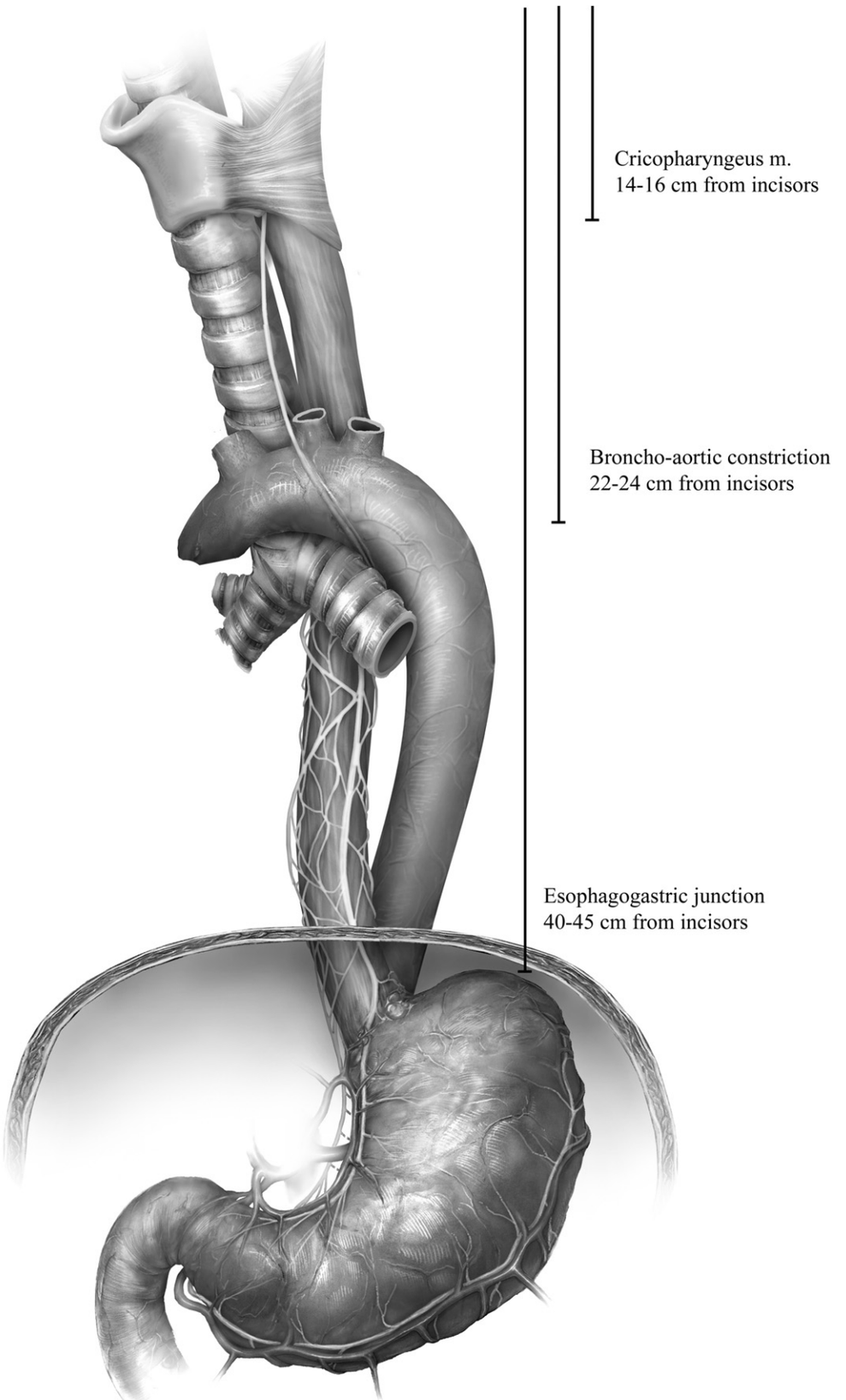

Figure 1 The esophagus has anatomical points of narrowing or constriction that make the organ prone to injury at these areas. The areas are the cricopharyngeus muscle of the cervical esophagus, the area of broncho-aortic constriction at the proximal one-third of the esophagus, and the distal esophagogastric junction. m. = muscle.

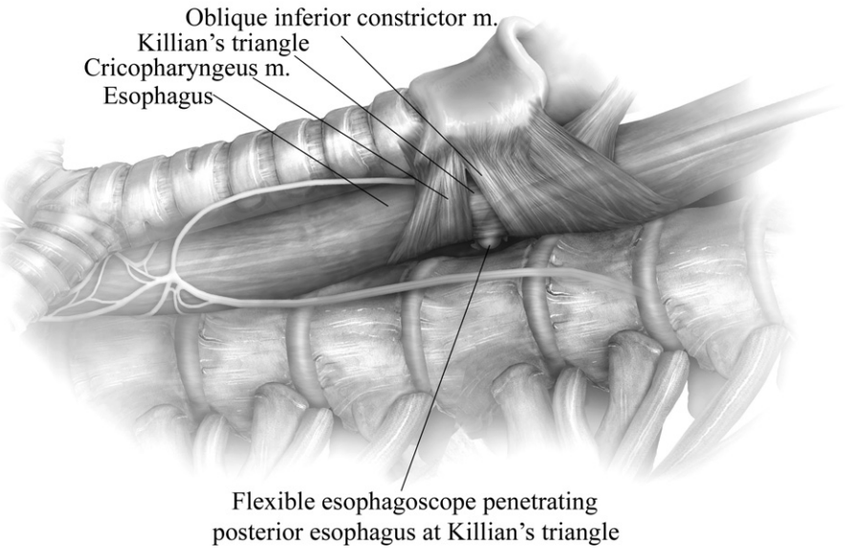

Figure 2 Iatrogenic cervical esophageal injuries commonly occur at Killian's triangle, which is a narrow area bordered by the horizontal cricopharyngeus muscle inferiorly and the oblique inferior constrictor muscles superiorly. The area within the triangle lacks posterior esophageal muscularis and is easily penetrated, as illustrated by the flexible esophagoscope. m. = muscle.

Operative Technique

Cervical Exploration

Neck exploration is the correct approach for cervical esophageal injuries as well as injuries to the proximal one-third of the thoracic esophagus down to the level of the carina. The majority of cervical esophageal injuries should be approached via the left neck. The patient is placed in the supine position and a shoulder roll is placed beneath the scapulae to extend the neck, and the arms are tucked to the sides. The patient's head is rotated slightly to the right to provide optimal exposure of the left neck (Fig. 3).

In the absence of distal obstruction, it is not necessary to repair a difficult to expose cervical esophageal injury, as the lesion will likely heal with adequate external drainage. However, the perforation should be primarily repaired if it is readily identified. For repair, a 40- or 46-F Maloney bougie is passed to prevent narrowing of the esophagus; a vertical esophageal myotomy is performed to expose the entire extent of the mucosal injury. The mucosal tear is repaired with interrupted 4-0 absorbable suture, and the muscularis is reapproximated with a running or interrupted 3-0 suture. The bougie is removed, and a nasogastric tube is inserted just proximal to the repair. The repair

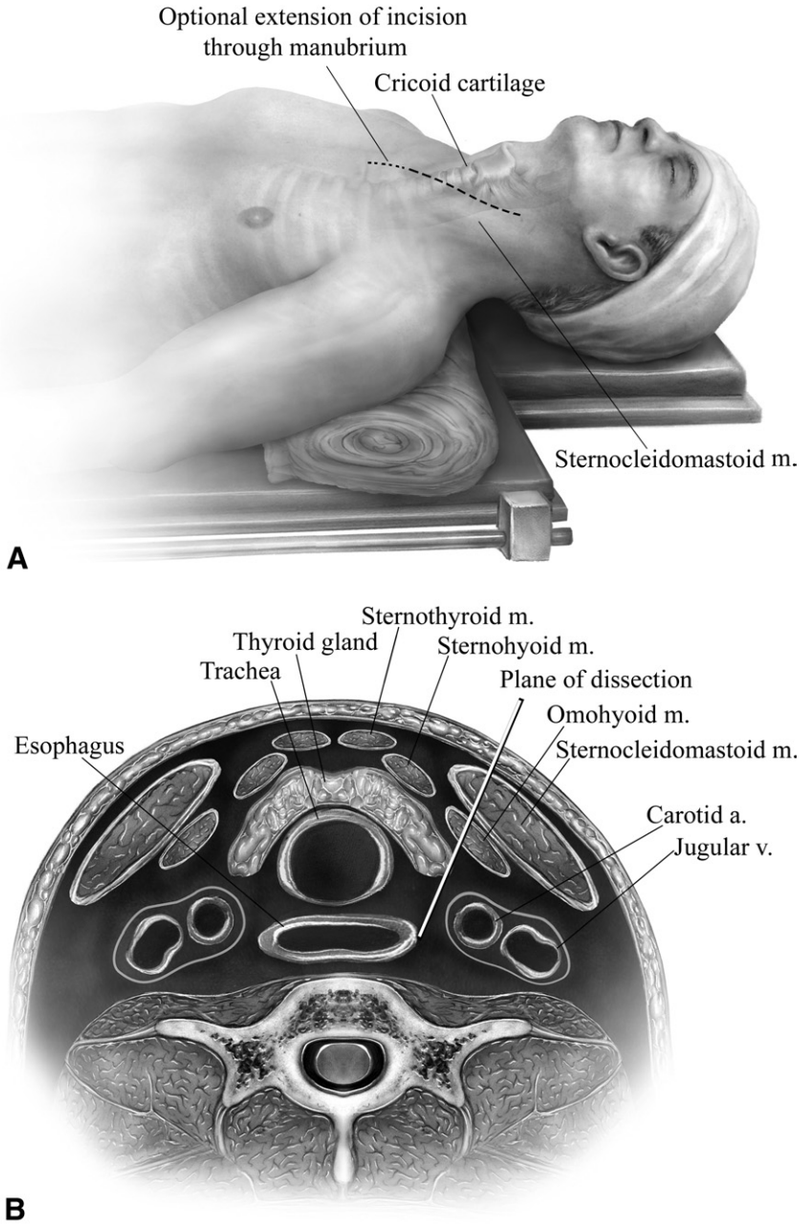

Figure 3 (A) The left neck is entered through a 5- to 7-cm incision along the anterior border of the sternocleidomastoid muscle (dashed line). The cricoid prominence is palpated as an external landmark, and one-third of the incision is made above the level of the cricoid cartilage, and two-thirds of the incision is extended below. If the esophageal injury involves the proximal one-third of the thoracic esophagus, the neck incision can be extended onto the sternum (dotted line), and the manubrium can be partially split to provide better access to the superior mediastinum. (B) The plane of the dissection is carried medial to the sternocleidomastoid muscle and carotid sheath, and lateral to the thyroid gland and trachea (bold line). a. = artery; m. = muscle; v. = vein.

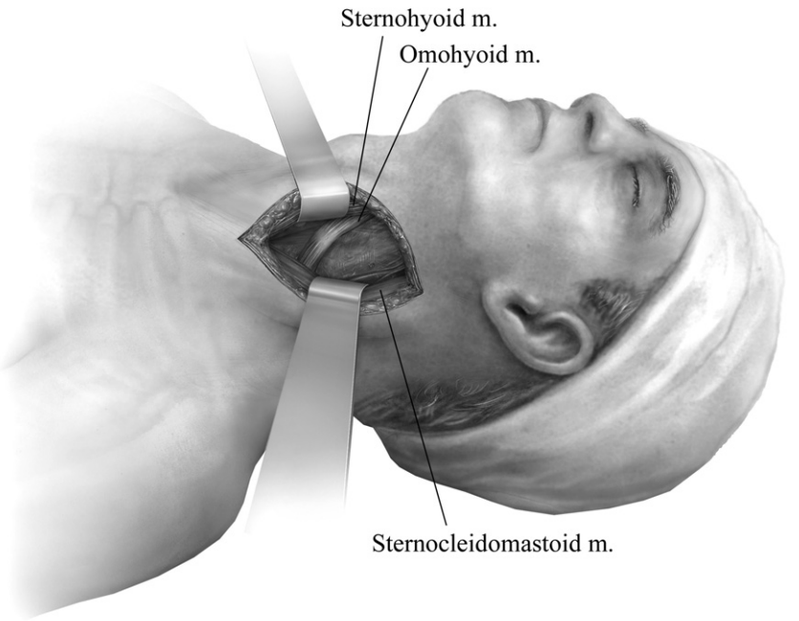

Figure 4 The incision is carried down through the platysma muscle, identifying the sternohyoid and omohyoid strap muscles, while the sternocleidomastoid muscle is retracted laterally with an Army–Navy retractor. The omohyoid muscle is divided, and its cut belly is followed down to the carotid sheath. m. = muscle.

is tested with the wound submerged under saline, and air is insufflated through the nasogastric tube while the distal esophagus is occluded by the surgeon's fingers. The nasogastric tube is then advanced past the repair and into the stomach (Figs. 4-9).

If the cervical esophagus could not be primarily repaired, the wound is left partially open, packed, and allowed to granulate close. The nasogastric tube is removed on postoperative day 3 and the patient is started on a clear liquid diet. A thin barium esophagogram is performed on postoperative day 7.

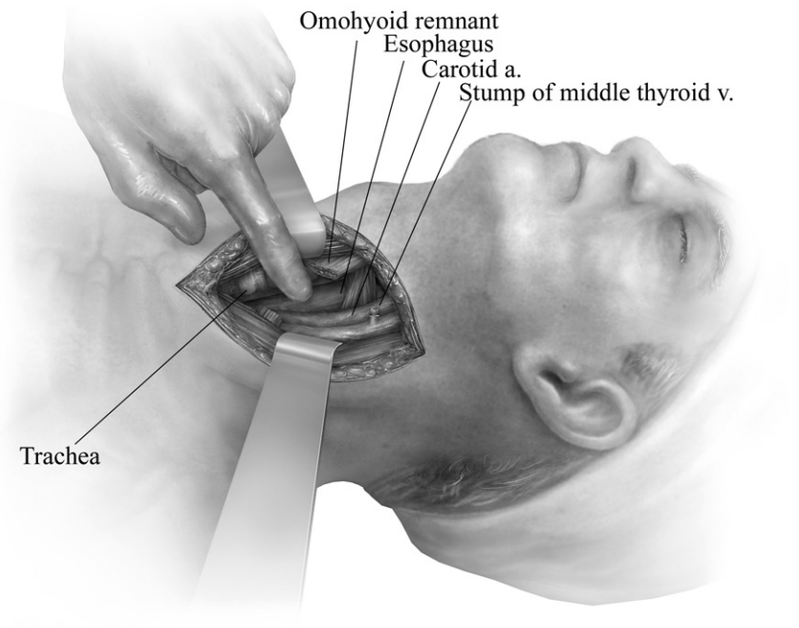

Figure 5 If necessary, the middle thyroid vein and inferior thyroid artery are divided if those vessels are in the surgeon's view. The trachea and thyroid gland are retracted medially by the assistant's finger, exposing the esophagus. Note a finger is used for retraction in the tracheoesophageal groove and not a metal retractor. A metal retractor such as an Army–Navy increases the risk of injury to the recurrent laryngeal nerve. Although care must be taken when placing retraction on the tracheoesophageal groove, identification of the recurrent laryngeal nerve is not necessary. a. artery; v. = vein.

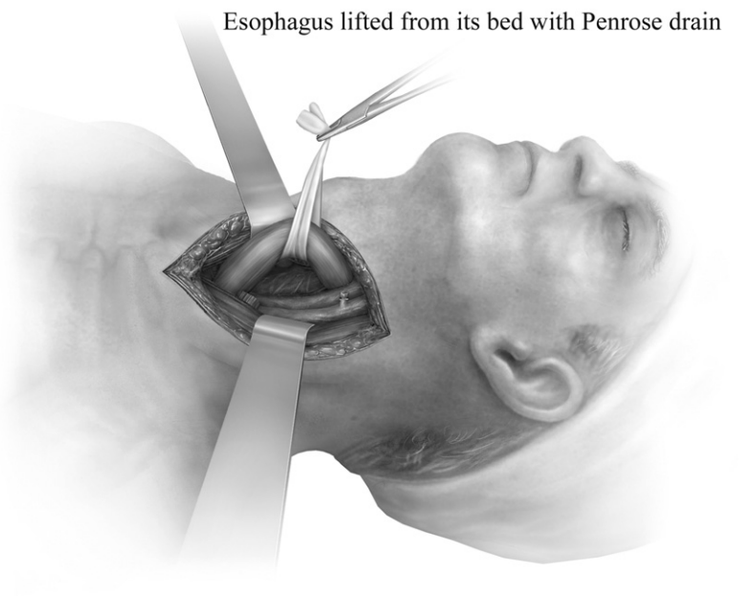

Figure 6 Although the trachea is retracted medially and the carotid is retracted laterally, the surgeon mobilizes the esophagus by encircling it with his or her finger, starting at the medial border of the esophagus and extending down posteriorly to the prevertebral fascia. This mobilization is performed using a combination of blunt dissection with a finger and sharp dissection with Metzabaum scissors. The mobilized esophagus is then encircled with a ¼-inch Penrose drain for easy traction.

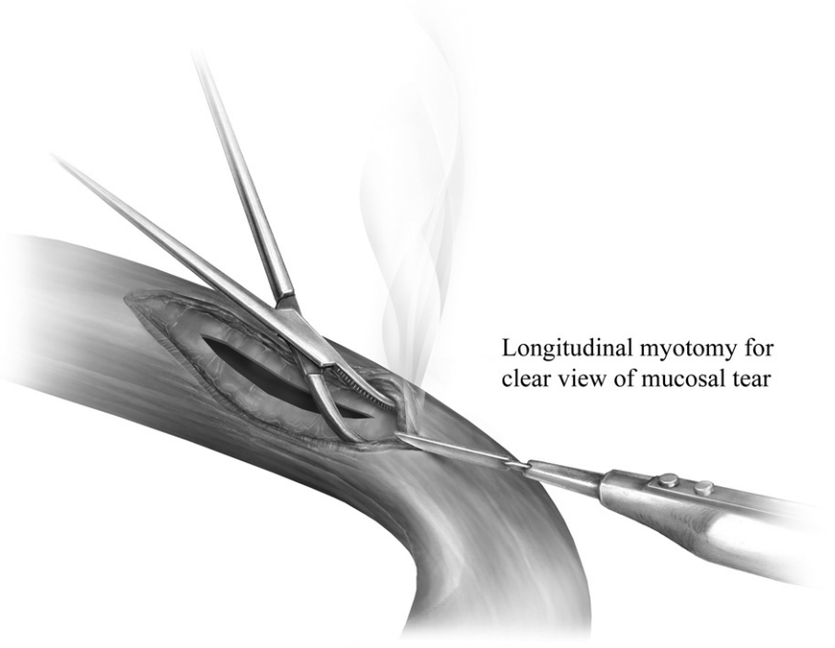

Figure 7 The mucosal injury is generally more extensive than the apparent muscularis defect. A longitudinal myotomy is performed with cautery until the full extent of the mucosal tear is apparent, and the mucosa is debrided, as necessary, to fresh edges.

Figure 8 After the esophageal repair, a finger is passed down posterior to the esophagus and anterior to the prevertebral fascia down into the superior mediastinum, followed by a sucker, to remove any fluid or effluent. A flat Blake drain is then placed into the superior mediastinum along this path and externalized, for closed drainage.

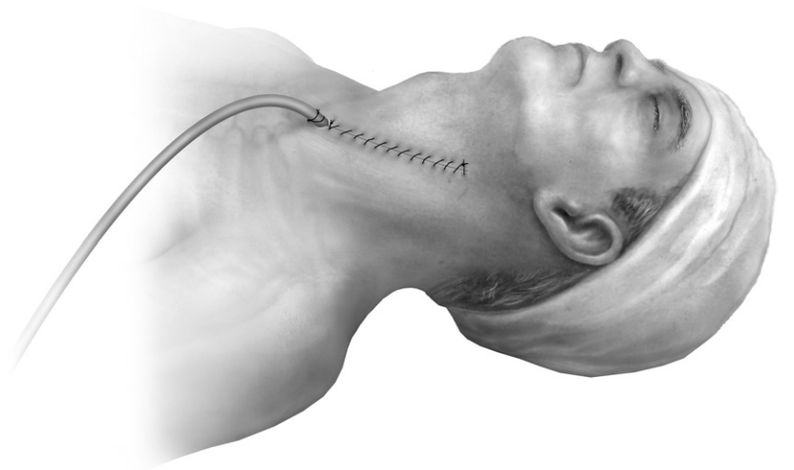

Figure 9 After the wound is copiously irrigated, the platysma muscle is closed with widely spaced interrupted 4-0 Vicryl sutures, and the skin is closed with a running 4-0 nylon suture.

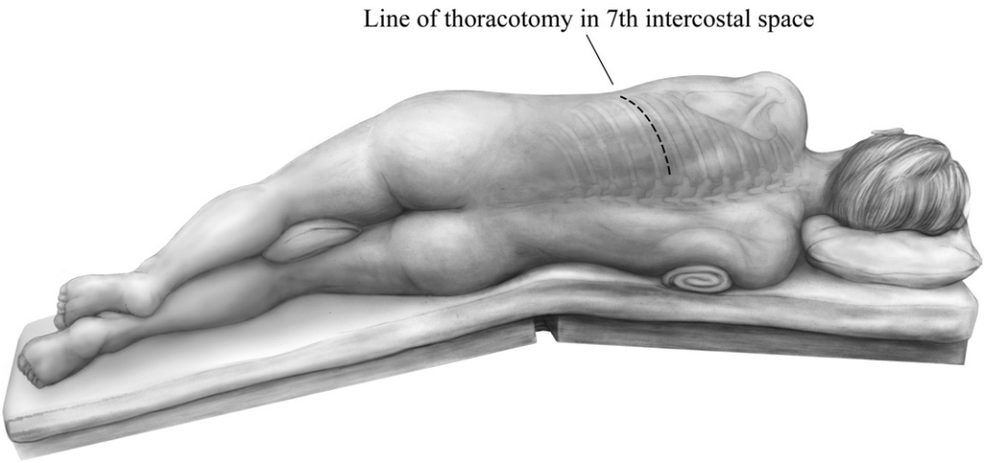

Figure 10 Injuries to the distal third of the esophagus are managed through the left side of the chest, via the seventh intercostal space. The patient is placed in the right lateral decubitus position, and a roll is placed just bellow the axilla, to protect the brachial plexus. The table is flexed to increase the intercostal spaces, and reverse Trendelenberg tilting of the table is provided until the thorax is parallel to the floor.

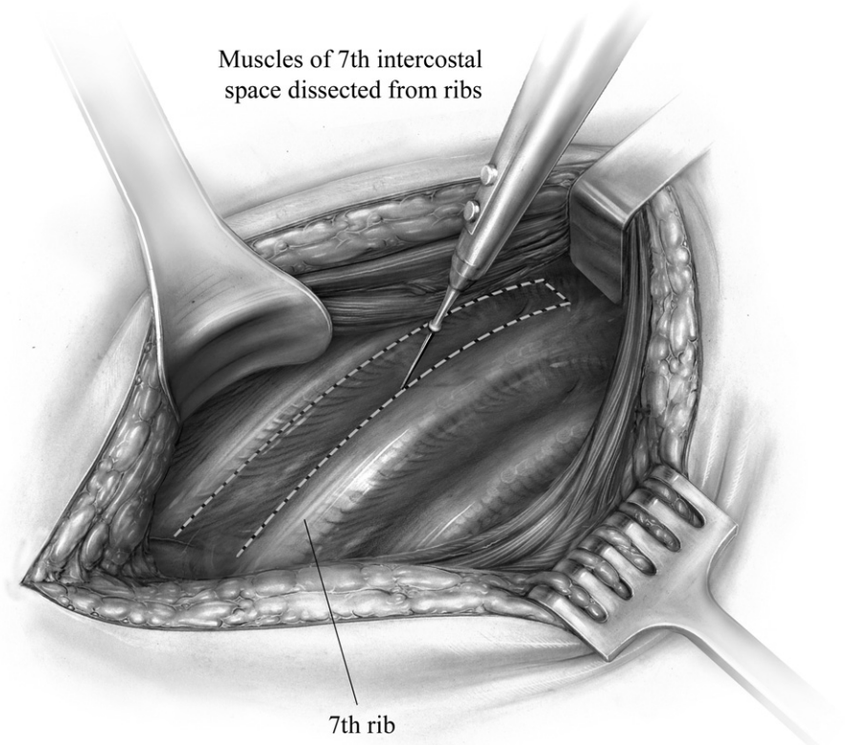

Figure 11 In harvesting an intercostal muscle flap for a reinforced repair, the muscle of the seventh interspace is carefully cauterized off of the seventh rib, and the neurovascular bundle is gently levered off of the rib with a periosteal elevator. The muscle is then cauterized off of the eighth rib. The muscle is divided anteriorly and mobilized posteriorly as a pedicle. It is wrapped in moist gauze and set aside until the end of the case.

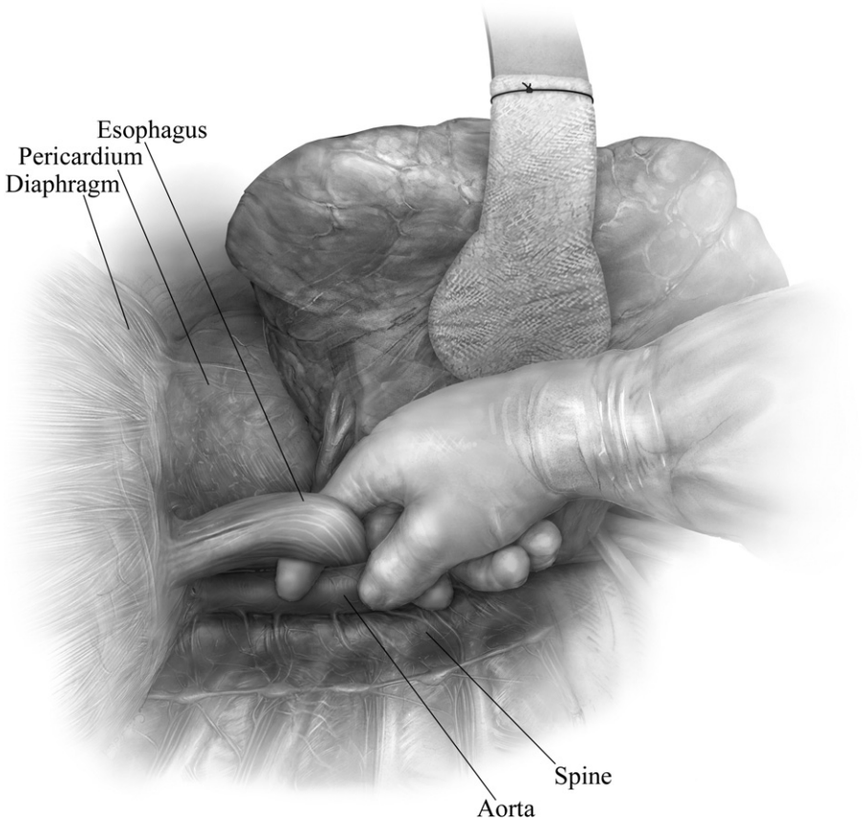

Figure 12 After the chest is entered, any effusion, succus, or debris is evacuated. The lung is retracted anteriorly with a cloth-covered Harrington retractor, or other type of lung retractor. Beginning near the esophageal hiatus of the diaphragm and between the aorta and the pericardium, the esophagus is mobilized with the surgeon's finger.

Thoracic Exploration

Perforations of the middle third of the esophagus are approached from the right side through the fourth through sixth intercostal space, depending on location, while injuries to the distal third of the esophagus are managed from the left side of the chest, through the seventh intercostal space (Fig.10). Single lung ventilation with a double lumen endotracheal tube may improve exposure; however, this is not necessary as the lung usually can be retracted aside. Reinforcement of the primary repair with an intercostal muscle flap, pericardial fat pad, pleural patch (Grillo patch), or omentum is not necessary but may be performed. The decision to reinforce the primary repair with an intercostal muscle flap must be made before thoracotomy (Figs. 11-13).

As mentioned in the cervical exploration section, the mucosal injury is usually more extensive than the apparent muscularis defect. A longitudinal myotomy is performed until the full extent of the mucosal tear is apparent, and the mucosa edges are debrided. The mucosa can be repaired with interrupted 4-0 Vicryl sutures. Whyte and coworkers described an effective technique of primary repair, where the mucosal edges are grasped and approximated with Allis clamps, and the mucosa is closed with a 3.5-mm load gastrointestinal anastomotic (GIA) surgical stapler (AutoSuture, Inc., Norwalk, CT)[4] (Fig. 14). The second layer of muscularis is closed with an interrupted or running 4-0 absorbable suture. At this time, the repair may be reinforced with the intercostal muscle pedicled flap (Fig.15). If the repair is to be reinforced with a pleural patch, only thickened inflamed parietal pleural is to be used. Normal parietal pleural is too thin and falls apart once harvested. Alternatively in some cases the pericardial fat pad provides good coverage. A nasogastric tube is inserted to just above the repair; while the closure is submerged under saline, it is tested by insufflating air and occluding the distal esophagus. The nasogastric tube is then advanced into the stomach. The mediastinum and chest are thoroughly irrigated; an angled 28-F chest tube is positioned over the diaphragm, and a straight 28-F chest tube is placed along the posterior thorax.

Draining gastrostomy and feeding jejunostomy tubes are generally not necessary. The nasogastric tube is left to low wall suction for 3 days and then removed. The patient is started on a clear liquid diet and slowly advanced. A thin barium swallow study is obtained on postoperative day 7.

Esophageal Stenting

Recently some groups have reported success in managing esophageal perforations with removable esophageal stents. Kiev and colleagues[8] have described their use of removable Polyflex esophageal stents (Rush, Inc., Teleflex Medical, Duluth, GA) in the treatment of 14 patients with esophageal perforations (5 of whom had continued leaks documented on contrast studies after primary surgical repair). All 14 patients had successful healing of the perforation without the need for additional surgical intervention. Oral intake in the majority was quickly resumed. In all patients,

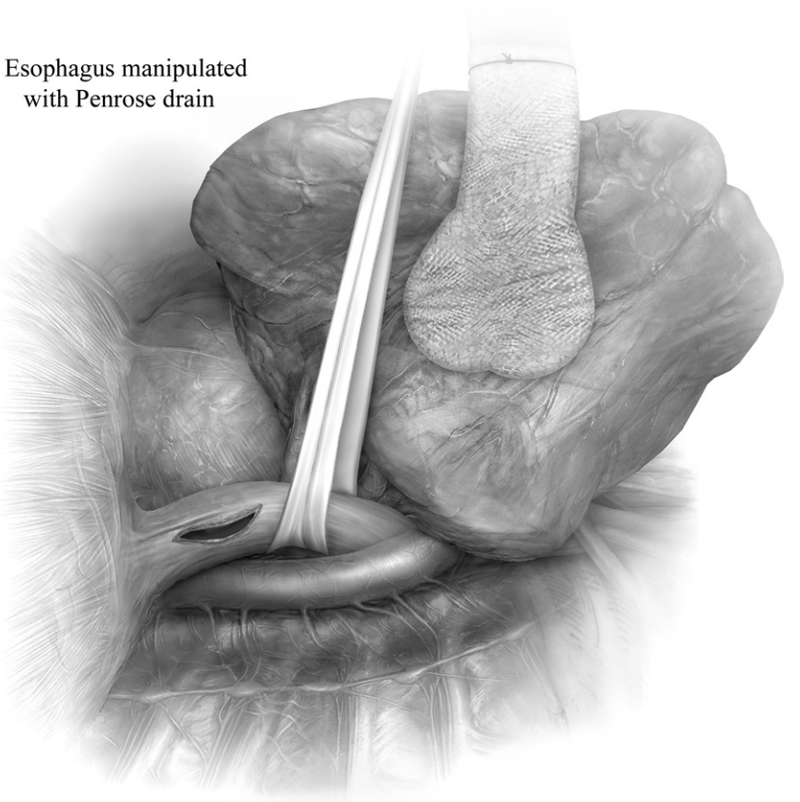

Figure 13 The esophagus is then encircled with a Penrose drain for easy manipulation.

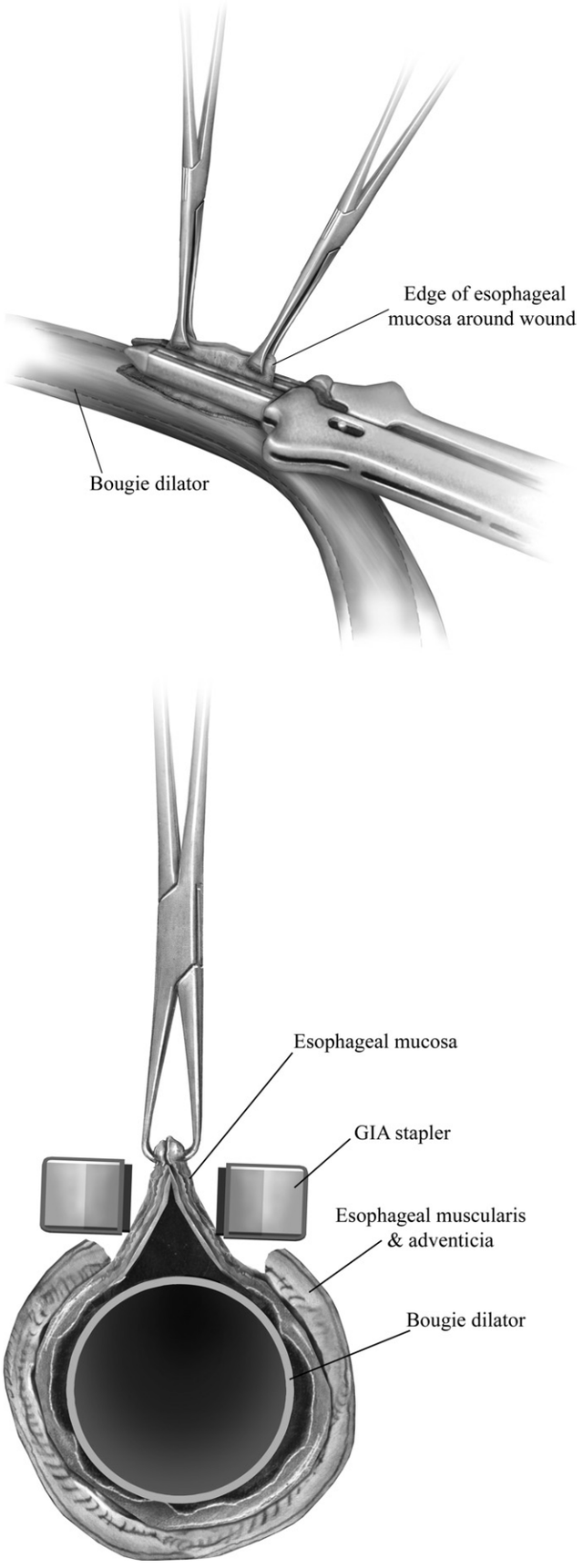

Figure 14 With a 40-F or 46-F Maloney bougie inserted into the lumen, the esophageal mucosal edges are grasped and approximated with Allis clamps, and the mucosa is closed with a 3.5-mm load GIA surgical stapler (AutoSuture, Inc., Norwalk, CT).

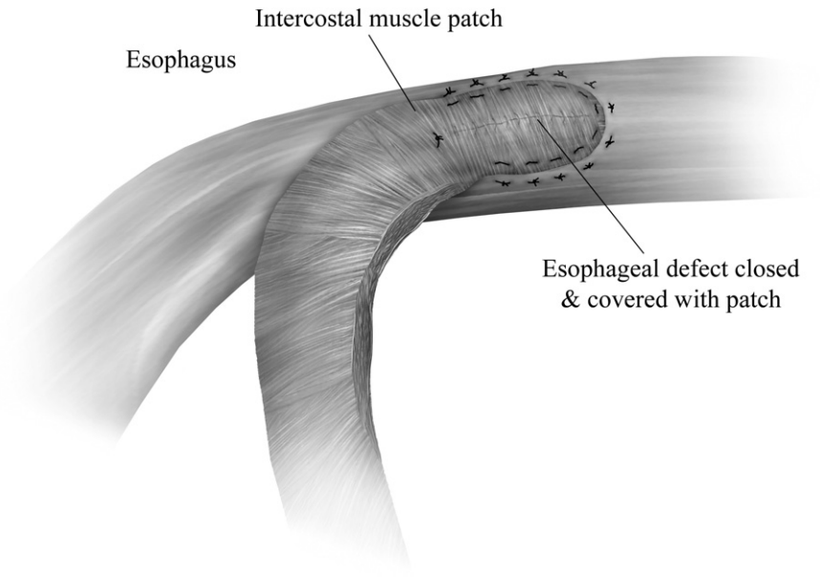

Figure 15 The second layer of muscularis is closed with an interrupted or running 4-0 absorbable suture. The repair may be reinforced with the intercostal muscle pedicled flap sewn in place with interrupted mattress sutures around the circumference of the flap.

this group placed percutaneous gastrostomy tubes to aid in nutrition as well as to keep the stomach decompressed. In general their patients were discharged with the stents in place and returned for reevaluation; usually the stent was removed within the 30-day period after stent deployment. Stent migration was a noted problem that required prompt identification and repositioning. Of note, the site of perforation is important in determining stent deployment with efforts made if possible to avoid stenting at or above the upper esophageal sphincter or across the gastroesophageal sphincter.

Conclusions

Successful outcomes for primary repair of esophageal perforation can be obtained even in delays in diagnosis greater than 24 hours. Wright and coworkers reported on 28 patients who underwent reinforced primary repair of thoracic esophageal injuries, with a total mortality of 14%.[3] Thirteen patients were treated >24 hours after their injury; of these 13 patients, there was a 31% mortality and a 54% leak rate. Whyte and coworkers described 22 patients with thoracic esophageal perforations who underwent primary repair.[4] The mortality rate for all patients was 5%. Nine patients underwent repair >24 hours after their initial injury, and 33% of those patients developed a postoperative leak.

Iannettoni and coworkers examined the long-term results of 42 patients treated for esophageal perforation.[9] The mean follow-up was 3.7 years, and the overall mortality was 16.7%. Of the 42 patients, 25 underwent primary repair of their esophageal perforation. Five of the patients who underwent primary repair (20%) developed postoperative leaks, and all five had preexisting gastroesophageal reflux disease (GERD) with peptic strictures. Forty percent of the primary repair patients required postoperative dilations for dysphagia, and five of those patients ultimately required esophagectomy for intractable GERD-related strictures.

Primary repair of esophageal perforations can be accomplished with favorable results. However, perforations due to instrumentation of GERD-related stricture may be better suited by esophagectomy at initial presentation, as postoperative dilation of these strictures to eliminate dysphagia is usually unsuccessful. Perforation as a result of instrumentation of achalasia can be treated by primary repair of the injury, long myotomy, and a Belsey antireflux operation. In the absence of primary malignancy or severe peptic stricture, primary repair of esophageal perforation is the optimal therapeutic approach. In the near future esophageal stenting for perforation may become the preferred treatment especially in cases without significant mediastinal soiling.

References

1. Brinster CJ, Singhal S, Lee L, et al: Evolving options in the management of esophageal perforation. Ann Thorac Surg 77:1475-1483, 2004
2. Grillo HC, Wilkins EW Jr: Esophageal repair following late diagnosis of intrathoracic perforation. Ann Thorac Surg 20:387-399, 1975
3. Wright CD, Mathisen DJ, Wain JC, et al: Reinforced primary repair of thoracic esophageal perforation. Ann Thorac Surg 60:245-248, 1995
4. Whyte RI, Iannettoni MD, Orringer MB: Intrathoracic esophageal perforation. The merit of primary repair. J Thorac Cardiovasc Surg 109:140-144, 1995
5. Boerhaave H: Atrocis, nec descripti prima, morbid historia. Derbes V, Mitchell R, translators. Bull Med Libr Assoc 43:217, 1955
6. Reich SB: Production of pulmonary edema by aspiration of water-soluble nonabsorbable contrast media. Radiology 92:367-370, 1969
7. Gollub MJ, Bains MS: Barium sulfate: a new (old) contrast agent for diagnosis of postoperative esophageal leaks. Radiology 202:360-362, 1997
8. Kiev J, Amendola M, Bouhaidar D, et al: A management algorithm for esophageal perforation. Am J Surg 194:103-106, 2007
9. Iannettoni MD, Vlessis AA, Whyte RI, et al: Functional outcome after surgical treatment of esophageal perforation. Ann Thorac Surg 64:1606-1609, 1997